



Operation IceBridge



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Image: M. Studinger

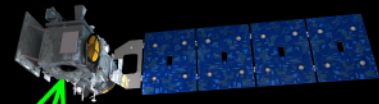


Operation IceBridge



CryoSat-2
2010 - 2015

ICESat-2

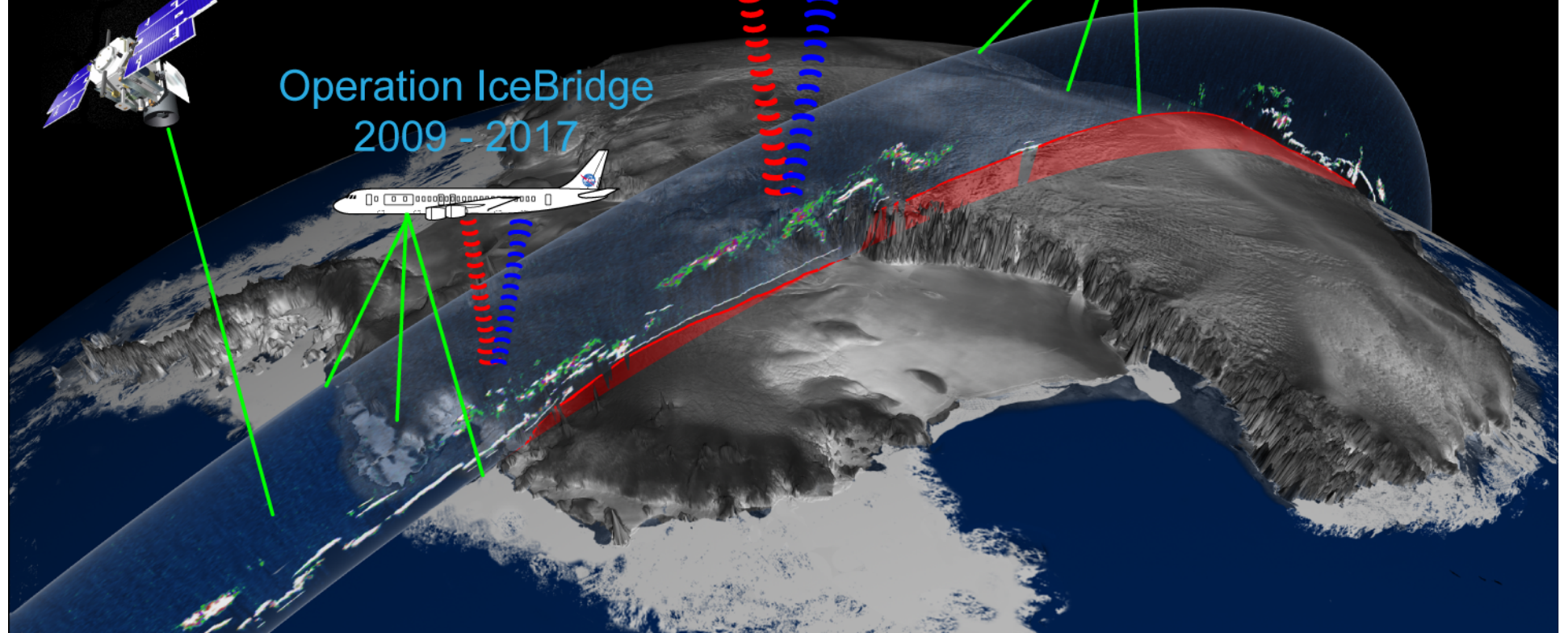
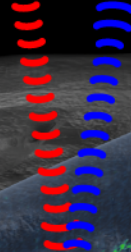
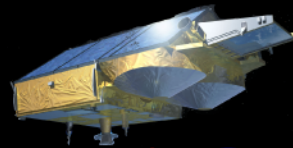


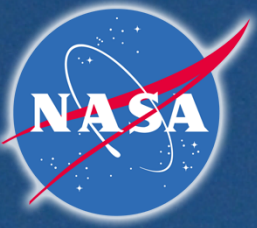
2016-2020

ICESat
2003 - 2009

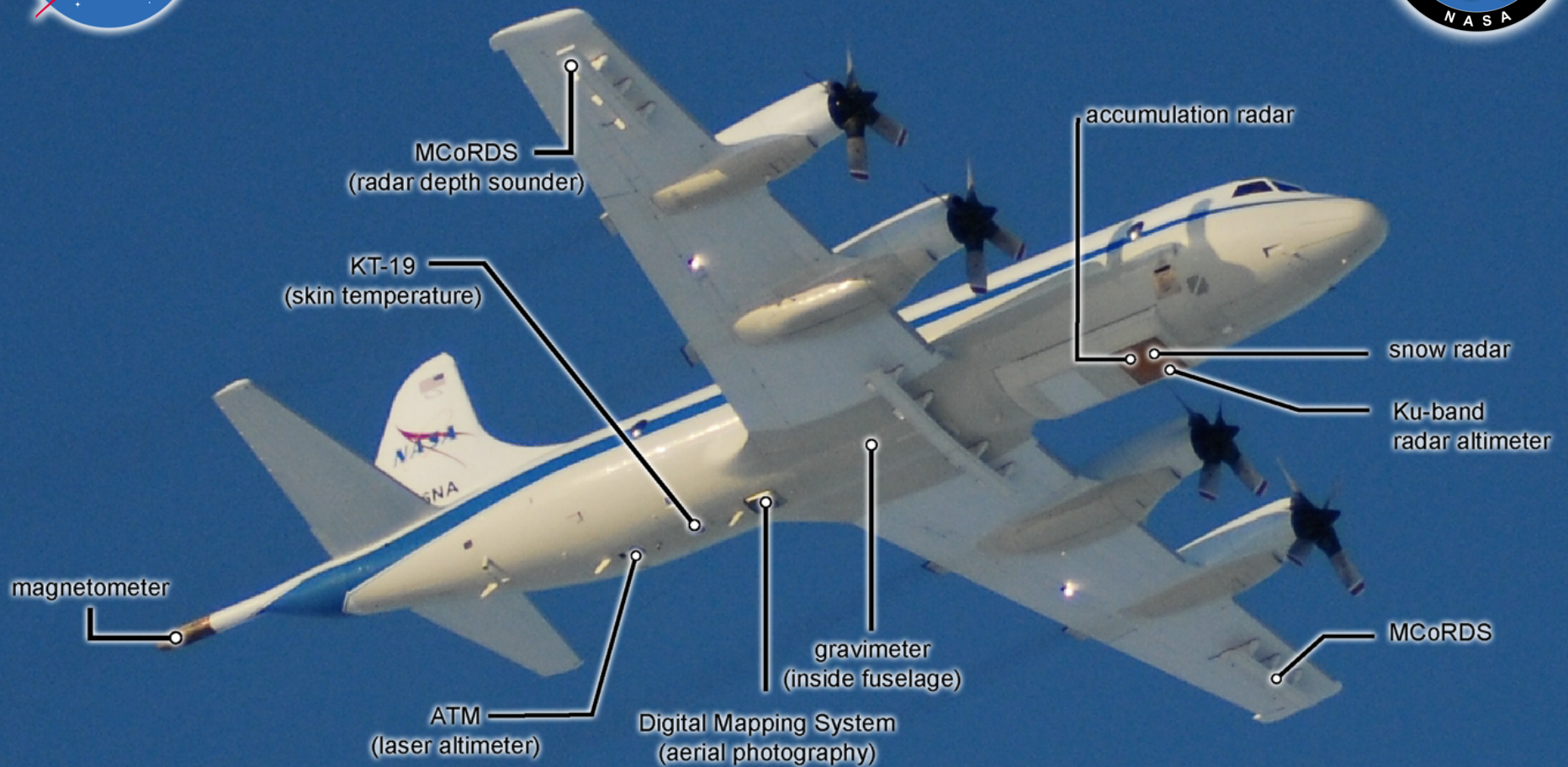


Operation IceBridge
2009 - 2017





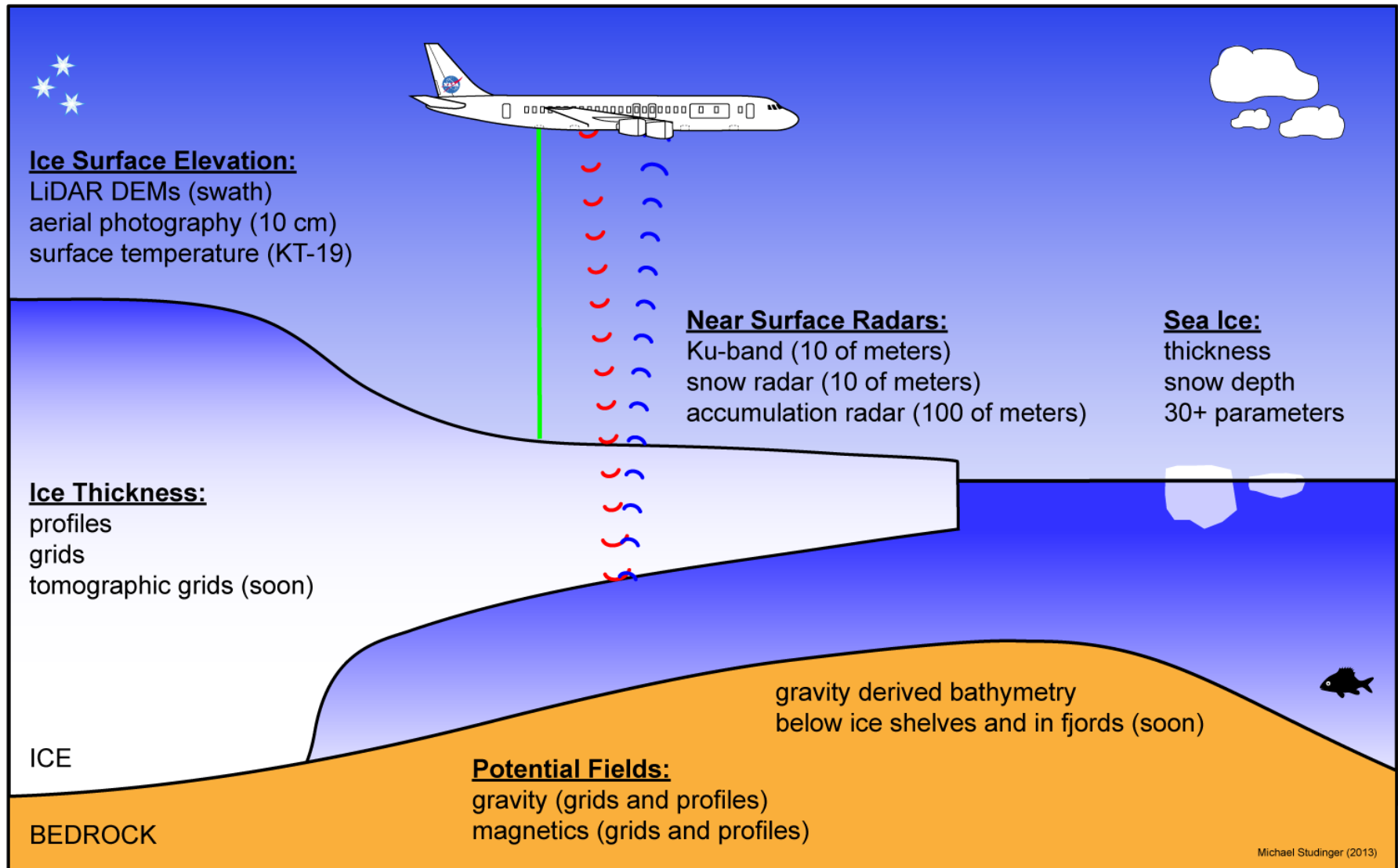
P-3 Aircraft and Instrument Suite

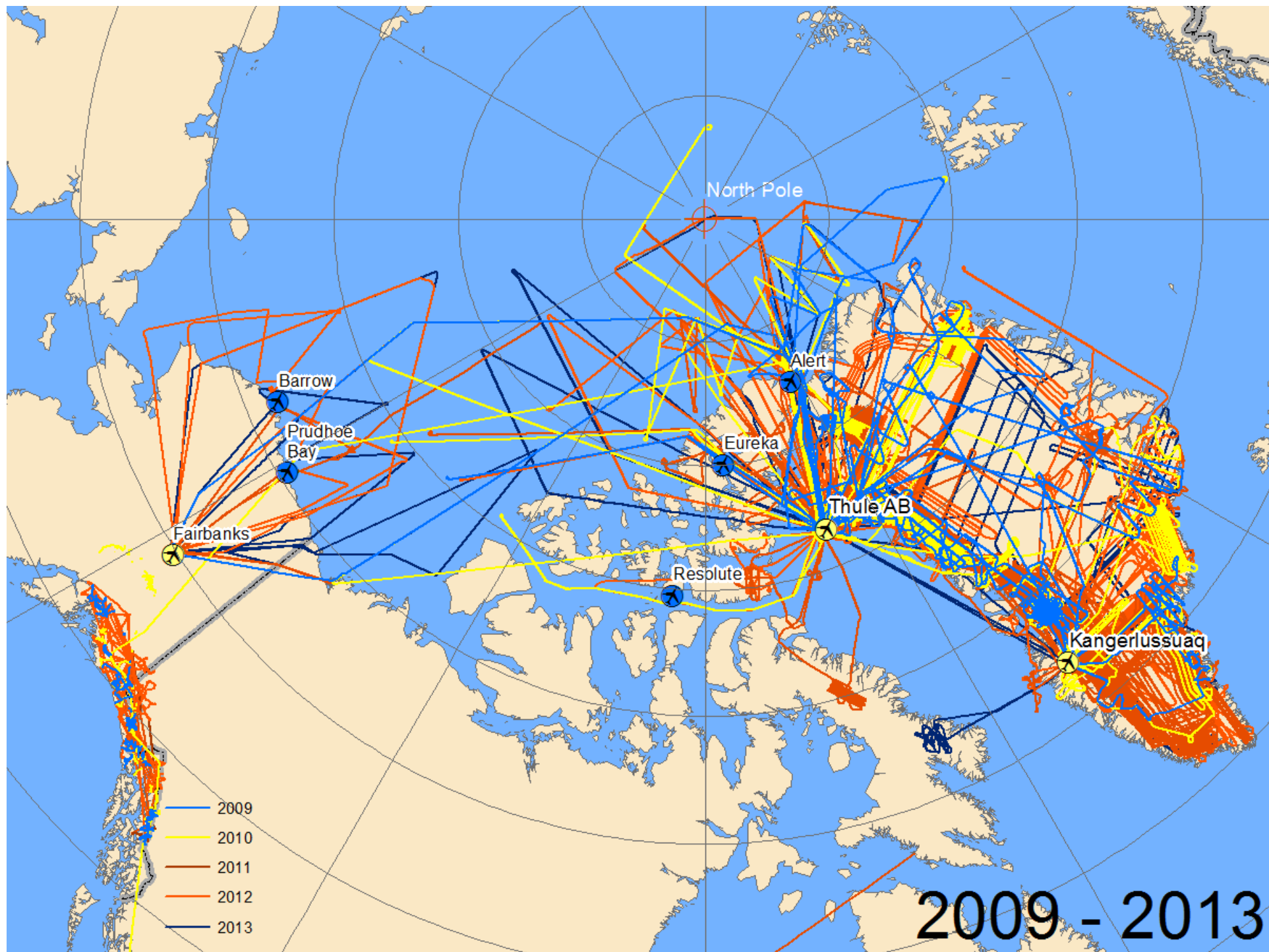


9 science instruments



IceBridge Data Products







Level 1 Science Requirements directly related to GRISO goals



- IS7. Collect elevation data so that the combined ICESat-OIB sampling provides an elevation measurement within 10-km for **90% of the area within 100-km of the edge of the continuous Greenland Ice Sheet**, as well the Antarctic Amundsen Sea Coast and Peninsula.
- IS8. **Measure ice thickness, gravity, surface, and bed elevation along central flowlines of the outlet glaciers in Greenland with terminus widths of 2 km or greater.** Measurements should extend at least 1.5 times farther than predicted outlet glacier valley dimensions. Repeat surface elevation measurements as practical.
- IS9. Measure once, **ice thickness, surface, and bed elevation across-flow transects at 3- and 8- km upstream of the terminus for each glacier in (8).** Repeat surface elevation measurements as practical.
- IS11. **Measure ice thickness, elevation, gravity and magnetic anomalies over 10 Greenland glaciers and 15 Antarctic glaciers that are rapidly changing now or are likely to change in the next 10 years.** Coverage should extend from the terminus to the elevation where velocities are about 50 m/yr. Over the fast flowing deep troughs, the grids must have 5-km spacing or better, with 10-km or better spacing on the surrounding regions of the lower catchment. Cycle through the glacier list for the duration of IceBridge.
- IS13. Measure once **surface elevation, ice thickness and seabed bathymetry beneath selected Antarctic Ice Shelves, along Greenland fjords where** we will collect a line along the center of the fjords and three lines across (one at the sill, one near the middle, and one near the glacier front) and beneath Greenland ice tongues.
- IS14. Acquire repeat radar, basal-echo-amplitude data with a relative radiometric calibration of 3 dB over 200 km for investigation of the **changing distribution of sub-glacial water.**



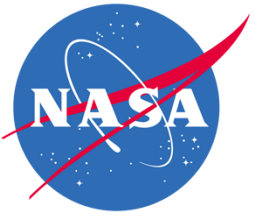
The way forward



- We have a physically based, **conceptual understanding** of many of the significant interactions that govern ice-ocean-atmosphere interactions.
 - To **transform this conceptual understanding into quantitative knowledge** it is necessary to acquire geographically diverse sets of fundamental observations over different time scales from hourly to daily to decadal and longer.
- Multi-sensor observations, in the water, on the ground, from the air and from space that need to be turned into time series.

Requires coordination and prioritization, good strategic planning and implementation.

White paper is an excellent start!

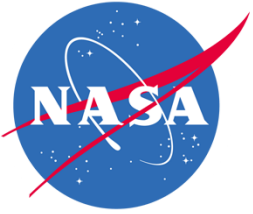


The Challenge: Bathymetry



- IceBridge: a “better-than-nothing” approach to estimate first-order bathymetry from airborne gravity. Tremendous progress but not the solution. Long-term value: provides guidance in identifying critical areas and prioritizing high-res data acquisition
- The challenge: fjords are inaccessible and no remote sensing techniques are available with sufficient accuracy and spatial resolution.
- *In-situ* measurements are unavoidable for water temperature, salinity, etc. (fleet of autonomous mini subs?)

Technological challenge with no immediate solution or even path forward.



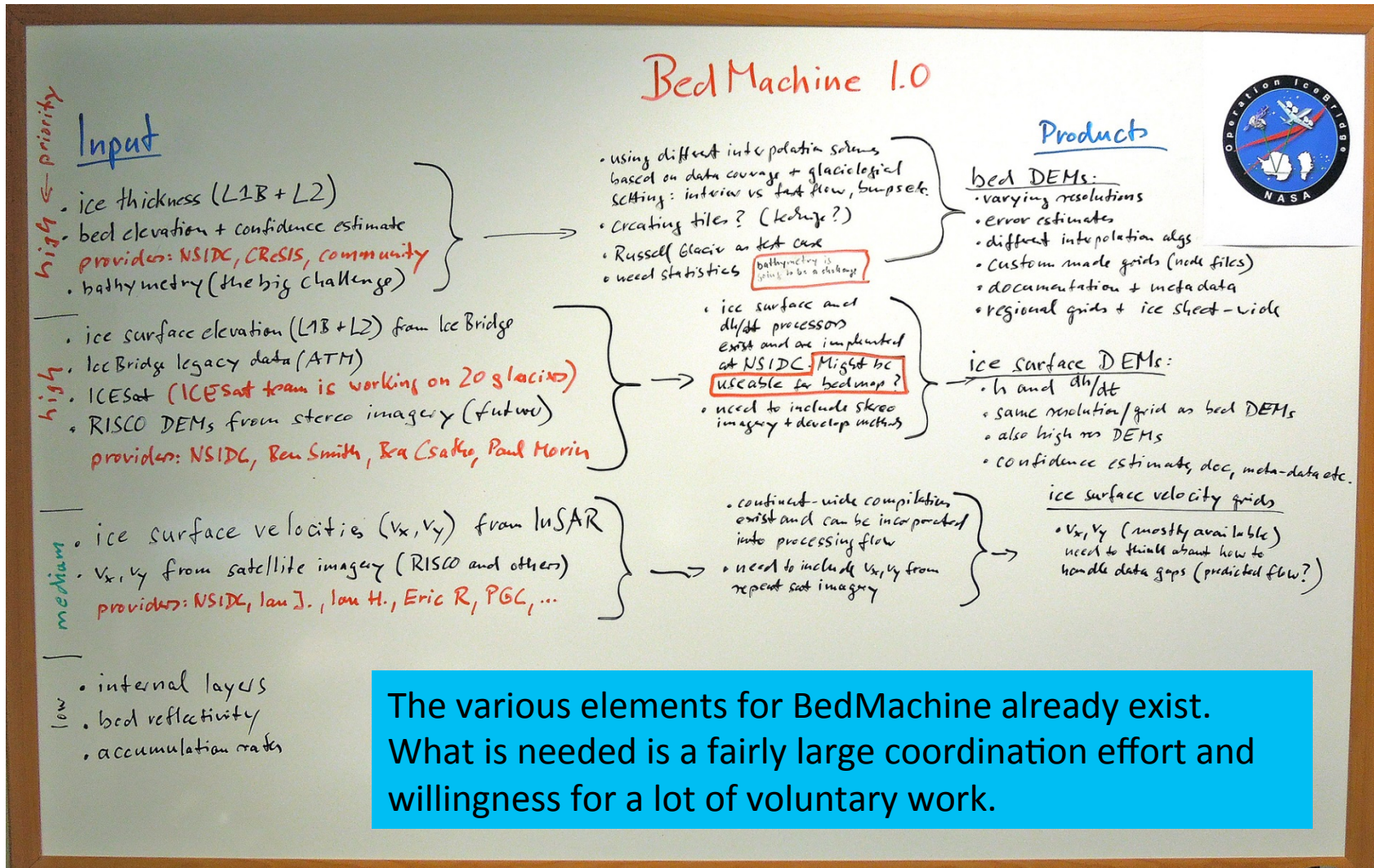
Turning Observations into Data Products



- Data collection is only the first step.
- Example: ice thickness measurements need to be turned into a continent-wide compilation that addresses the needs of a diverse community of ice sheet modelers with different needs. Also need to add bathymetry.
- Quality control and consistency checking is an enormous task. Small artifacts and errors in ice thickness data can create large artifacts and instabilities in ice sheet models. Community-based editing a la OpenStreetMap?
- Proprietary data, funding, and coordination remain issues that need to be resolved.
- Significant recent progress at JPL (Morlighem, Larour, Rignot, Seroussi, and others)



BedMachine 1.0?





Operation IceBridge



Operation IceBridge:

<http://www.nasa.gov/icebridge>

Science Website:

<http://icebridge.gsfc.nasa.gov/>

Data is available at
National Snow and Ice Data Center

<http://nsidc.org/data/icebridge/>

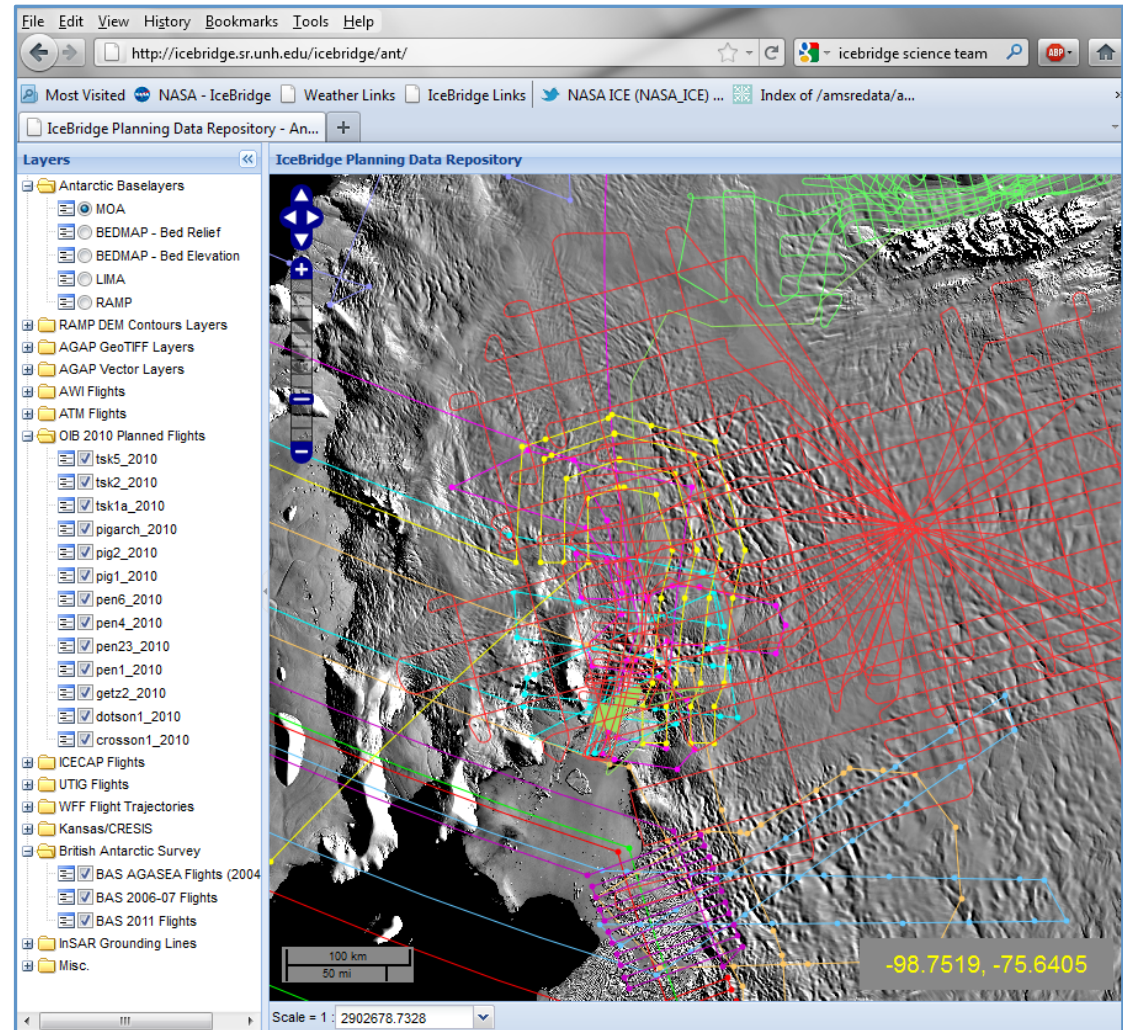
No period of exclusivity!

Flight planning tool:

<http://icebridge.sr.unh.edu/>

Social Media:

Facebook and Twitter, Flickr, etc.



BACKUP SLIDES



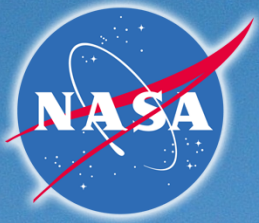
IceBridge Background



- 2008: feasibility and cost analysis: “An analysis and summary of options for collecting ICESat-like data from aircraft”
- 2009: solicited proposals for instruments for Antarctic campaigns 2009 and Arctic campaign 2010
ad hoc community-based steering committee responsible for flight planning
- 2010: ROSES call for instrument teams and IceBridge Science Team members
IceBridge Science Team and instrument teams selected based on competitive proposals
**shift from ad hoc steering committee to directed mission:
level 1 science requirements and science justification**
- 2011: ROSES call for IceBridge science proposals
- 2012: ROSES call for next phase of IceBridge (instrument teams)
- 2013: ROSES call for IceBridge Science Team

IceBridge is a directed mission.

Project resources are available to meet level 1 science requirements and mission goals, rather than support for individual PI-led projects.



Operation IceBridge



- IceBridge images Earth's polar ice in unprecedented detail to better understand processes that connect the polar regions with the global climate system.
- IceBridge utilizes a highly specialized fleet of research aircraft and the most sophisticated suite of innovative science instruments ever assembled to characterize annual changes in thickness of sea ice, glaciers, and ice sheets.
- In addition, IceBridge collects critical data used to predict the response of Earth's polar ice to climate change and resulting sea-level rise.
- IceBridge also helps bridge the gap in polar observations between NASA's ICESat satellite missions.

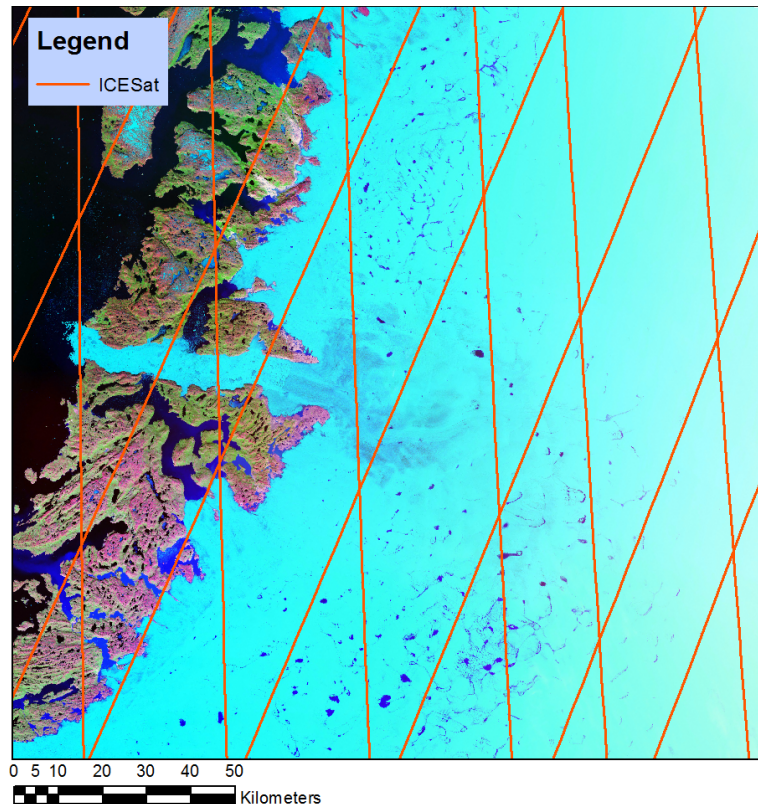




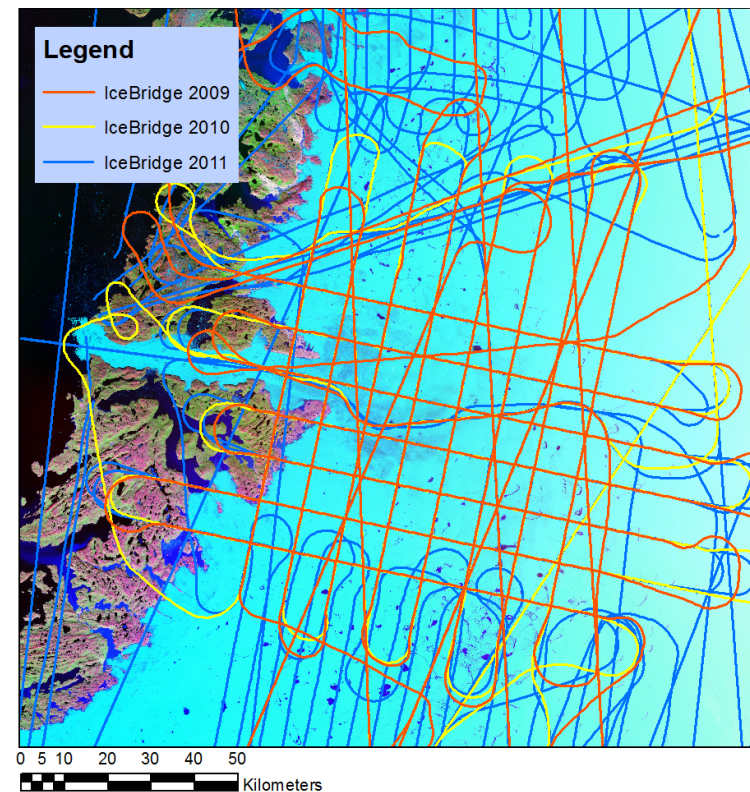
IceBridge Multi-Sensor Coverage



Jakobshavn Isbræ is the largest and fastest glacier draining the Greenland Ice Sheet and is discharging about 30 km^3 ice per year. The image below shows the large spacing between ICESat tracks with laser altimeter data. The data set is not suitable for monitoring critical processes and be able to turn the knowledge into predictive models of sea level rise.

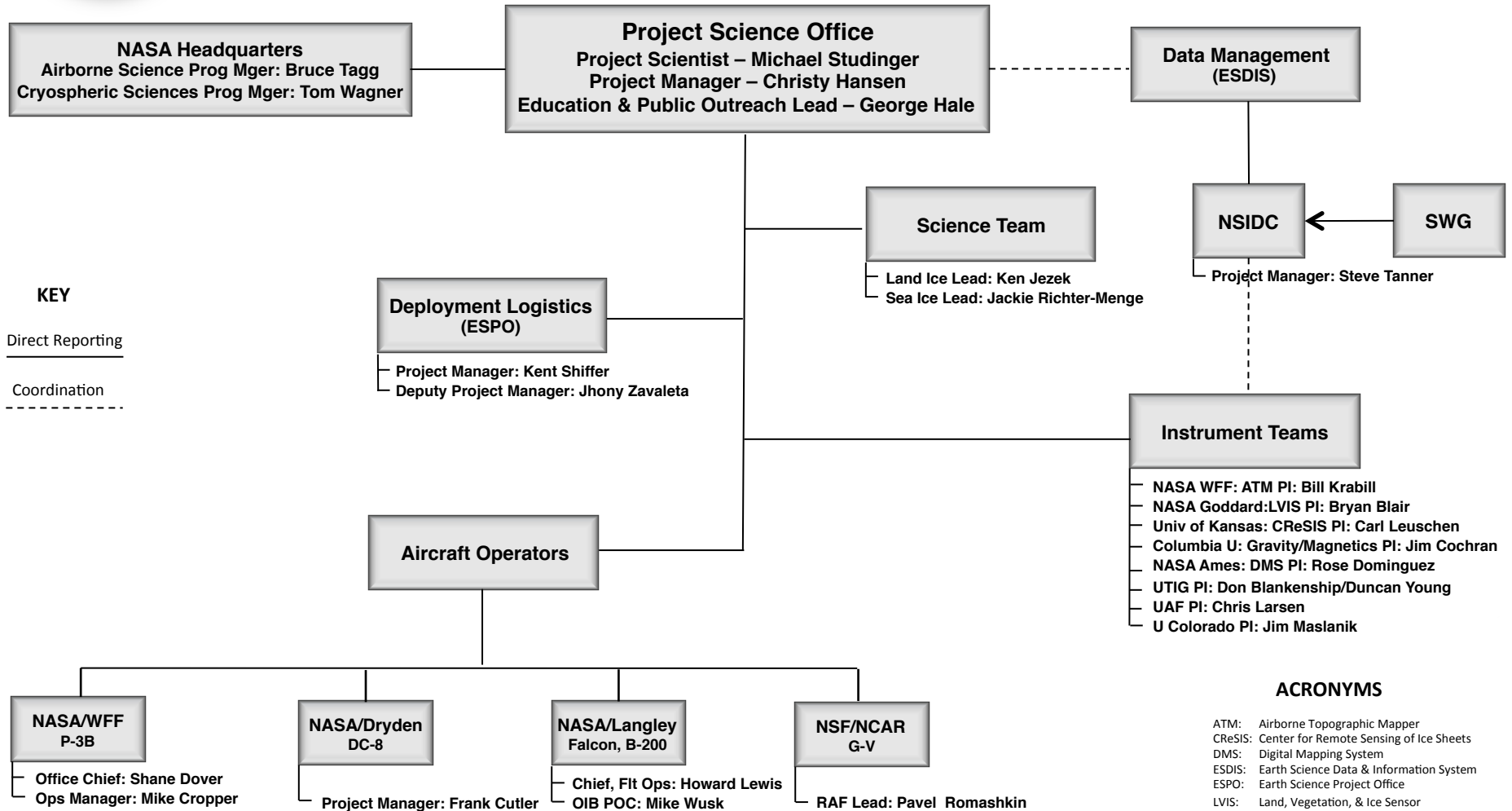


IceBridge adds detailed coverage that will transform our conceptual understanding of physical processes into quantitative knowledge for input into predictive models. **The image below shows a dense grid of IceBridge flight lines that includes 8 different instruments to image the glacier from the surface to the bed.**





Operation IceBridge Project Organization



ACRONYMS

ATM:	Airborne Topographic Mapper
CReSIS:	Center for Remote Sensing of Ice Sheets
DMS:	Digital Mapping System
ESDIS:	Earth Science Data & Information System
ESPO:	Earth Science Project Office
LVIS:	Land, Vegetation, & Ice Sensor
NCAR:	National Center for Atmospheric Research
NSF:	National Science Foundation
NSIDC:	National Snow & Ice Data Center
PI:	Principal Investigator
RAF:	Research Aviation Facility
SWG:	Science Working Group
UAF:	University of Alaska - Fairbanks
UTIG:	University of Texas Institute for Geophysics